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Research Article

Properties and Features of Residual Coastal Automorphic Salt Solonchaks of the Dried Bottom of the Aral Sea

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Abstract

The article presents new information obtained about the properties of residual coastal automorphic salt solonchaks, widespread on the dried bottom of the Aral Sea. Data on the mechanical composition, as well as the results of agrochemical analyzes of residual coastal automorphic salt solonchaks are presented. One of the important results obtained is that alluvial deposits consist mainly of particles of heavy and medium loamy mechanical composition, and the amount of physical clay particles (<0.01 mm) in clays is 60.6-68.6%, in heavy loams - 56-59.2%, and in medium loams - 31.4-43.6%, in some areas sandy loam and sandy horizons are also found. The article also presents the degree of salinity and the composition of absorbed cations of residual coastal automorphic solonchaks of the dried bottom of the Aral Sea, from which it is clear that the amount of absorbed bases (absorption capacity) in the upper layer of residual coastal automorphic solonchaks is 10.75-34.80 mEq per 100 grams of soil, and in the lower layers - 16.57-16.80 mEq. In the composition of the absorbed cations of automorphic solonchaks of the dried bottom of the Aral Sea, magnesium and sodium cations predominate, and the amount of calcium in the total composition is 11.49-31.63%, magnesium - 1.09-3.53%, sodium - 20.18-54 .65%, and mainly consist of soils with varying degrees of salinity (<10% mg/kg).

Keywords: *dry part of the Aral Sea, automorphic solonchaks along the residual sea, mechanical composition, humus, biogenic elements, absorption capacity.*

INTRODUCTION

Today, more than a third of all soils in the world are already degraded. In arid regions, this process turns into desertification. Land degradation as a result of climate change, agricultural expansion, urbanization and infrastructure construction leads to serious environmental and economic consequences. Which leads to a deterioration in the well-being of more than 3.2 billion people.

Land degradation on our planet directly affects half of humanity and threatens almost half of the world's gross domestic product. If nothing changes, it is predicted that by 2050 degraded land will cover an area equal to the size of South America." For this reason, the conservation and restoration of soil fertility, as well as the efficient use of land resources by preventing or mitigating drought, desertification and soil degradation processes caused by global climate change, are of great importance in all countries of the world [1].

Today, due to the drying up of the Aral Sea, the ecological and natural balance has been disrupted in recent years, and climate change is not for the better. As a result of the rise of sand-dust-salt deposits into the atmosphere, serious harm is caused to the population living in the region, as well as to the flora and fauna. As a result of increased secondary salinization, the yield of agricultural crops, gardens and vineyards is reduced.

The drying up of the Aral Sea remains a particularly pressing issue for the population living in this region. According to some data, due to the drying up of the sea and the acceleration of salinization processes in recent years, 50 thousand

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hectares of once arable land have gone out of agricultural use. A new desert, the "Aralkum", with an area of 5.5 million hectares, has formed in place of the dried up sea [2].

The President of Uzbekistan Shavkat Miramonovich Mirziyoyev in his speech at the meeting of the leaders of the founding countries of the International Fund for Saving the Aral Sea, held in the city of Turkmenbashi of the Republic of Turkmenistan, said, "It is necessary to focus on the issues of strengthening sand slides, reducing the rise of toxic aerosol dust from the dried-up part of the Aral Sea into the air. For this purpose, it is advisable to create a Regional Center for growing seedlings of forage plants resistant to desert conditions. According to the information provided by our scientists, we will be able to turn the dried-up part of the sea into groves and shrubs in 10-12 years. In addition, we will be able to create new fertile pastures, which will allow us to consistently develop livestock farming and provide jobs for tens of thousands of people. The regional center, in turn, will become a unique scientific and educational base for training in-demand specialists," he suggested.

According to Zinoviy Novitsky “According to my calculations, this process will take 10 years, and I hope that it will be completed successfully”. Today, mainly seeds and seedlings of desert plants are planted, such as saxaul, kandym, and solyanka.

For this reason, it is important to determine the properties and characteristics of the soils formed and developed on the dried bottom of the Aral Sea, analyze the changes occurring in them and scientific research to prevent degradation processes.

The objects of the study were the territories of the Republic of Karakalpakstan, located in the lower reaches of the Amu Darya around the Aral Sea, as well as the desert-sandy soils of the Aralkum desert, formed as a result of the decrease in sea level, in its north-eastern and southern parts.

MATERIALS AND METHODS

According to scientists' calculations, plants will need at least 40-45 years to fully recover and completely cover the bottom of the Aral Sea. But during these 40-45 years, dust rising from the dried-up bottom of the sea can reach other territories, as a result of which the socio-economic situation of the population in these territories can worsen and other similar negative processes can occur. It is known that nature has the potential for self-restoration, but human intervention can accelerate this process [3, 4].

The drying up of the Aral Sea attracts the attention of many researchers, agricultural specialists and ecologists. Since the 70s of the last centuries, a number of researchers have been working, such as geographers, geologists, hydrogeologists, geobotanists, soil scientists. But direct soil studies were conducted only in the river delta and partly in the territory of the former "living" deltas. However, the soil cover is a "mirror" of the landscape, which is formed as a result of the interaction of all natural and anthropogenic factors. Such abnormal and rapid changes in natural conditions were not observed in the previous period. For this reason, the formation of the soil cover on the dried bottom of the Aral does not correspond to the patterns known to date. Because, according to sources, a decrease in the water level of the Aral Sea was observed in previous periods. But this process, the reduction of river water, the emergence of ancient dry deltas, occurred gradually over many years.

On the dried-out bottom of the Aral Sea, the process of soil formation takes place in very complex hydrothermal conditions, over hydrogeologically highly saline rocks, and separate types of marine salt marshes are formed.

They are divided into automorphic, hydromorphic and semi-hydromorphic. In addition to coastal salt solonchaks, a complex of desert sandy soils and sands develops here.

Desert sandy soils formed on flat and plain sands develop in automorphic conditions [5, 6, 7, 8, 9]. Thus, the following systematic list of soils of the dried part of the Aral Sea can be given:

1. Sandy desert soils;
2. Hydromorphic and semi-hydromorphic sandy desert soils;
3. Coastal residual solonchaks;
4. Coastal automorphic solonchaks;
5. Coastal semi-hydromorphic solonchaks;
6. Coastal hydromorphic solonchaks;
7. Sandy- solonchak complex of the Akpetkinsky massif;

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Coastal residual solonchaks. These solonchaks are widespread in the southern part of the dried bottom and are a natural continuation of the alluvial delta of the Amu Darya. In some places, many shells are found. Alluvial deposits that make up their thickness mainly consist of the remains of particles of heavy and medium loamy mechanical composition, the amount of physical clay particles (<0.01 mm) is 60.6-68.6% in clays, 56-59.2% in heavy loams and 31.4-43.6% in medium loams, in some sections there are also sandy loams and sandy layers.

The mechanical composition of the soil throughout the profile contains many particles of large dust and silt (Table 1). As a result of drying, the volume of the soil decreases significantly, and cracks form.

Table 1.
Mechanical composition of coastal automorphic residual salt marshes of the dried bottom of the Aral Sea

№ section	Depth of horizon, cm	Soil particle content, in %, size in mm							Physical clay	Mechanical composition
		sand			clay			silt		
		>0,25	0,25-0,1	0,1-0,05	0,05-0,01	0,01-0,005	0,005-0,001	0,001	<0,01 мм	
1	0-20	29,6	7,4	29	16,6	6,1	6,3	5	17,4	sandy loam
	20-44	32,4	8,1	24,3	17,3	11,3	4,6	2	17,9	sandy loam
	44-64	34,8	8,7	7,3	19,6	16,1	3,5	0	19,6	sandy loam
	64-76	24,4	6,1	9,4	19,3	21,1	13,5	6,2	40,8	Medium loam
	76-91	52	13,2	2,6	17,1	5,1	6,3	3,7	15,1	sandy loam
2	0-13	13,6	3,4	16,5	35,1	12,8	9,9	8,7	31,4	Medium loam
	13-21	2,4	0,6	3,8	37,2	30,3	13,1	12,6	56	Heavy loam
	21-43	1,6	0,4	6,5	31,9	31,1	18,5	10	59,6	Heavy loam
	43-71	1,2	0,3	8,2	21,7	26,8	30	11,8	68,6	clay
	71-150	2,4	0,6	9	27,4	31,6	21,7	7,3	60,6	clay
35	0-23	52,8	13,2	12,9	15,4	2,6	0,9	2,2	5,7	sand
	23-38	4,8	1,2	25,5	54,0	6,5	4,2	3,8	14,5	sandy loam
	38-50	20	5	5,7	50,8	8,4	6,5	3,6	18,5	sandy loam
	50-71	0,8	0,2	18,3	37,1	22,3	11,8	9,5	43,6	Medium loam
	71-83	15,6	3,9	15	52,1	7,7	3,0	2,7	13,4	sandy loam
	83-115	1,2	0,3	37	26,9	22,6	7,7	4,3	34,6	Medium loam
	115-134	1,6	0,4	13,2	63,1	12,2	3,6	5,9	21,7	Light loam
	134-158	0,8	0,2	1,7	38,1	30,8	18,1	10,3	59,2	Heavy loam

It was established that the humus content in the studied coastal residual automorphic solonchaks in the upper layer is 0.607-0.992% and decreases to 0.232-0.397% in the lower layers (Table 2).

The amount of humus and nutrients in automorphic soils of the coast of the residual sea on the dried bottom of the Aral Sea, %, mg/kg

№ section	Depth of horizon, cm	Humus, %	C: N	Total, in %			Mobile, in mg/kg			Carbonate
				Nitrogen	Phosphorus	Potassium	$N\text{-}NO_3$	P_2O_5	K_2O	CO_2 %
1	0-20	0,635	8,2	0,045	0,307	0,828	12,4	21,1	427	8,978
	20-44	0,496	7,4	0,039	0,283	0,774	10,8	9,32	288	7,392
	44-64	0,248	8,0	0,018	0,173	0,594	9,78	6,10	182	5,280
	64-76	0,232	8,4	0,016	0,107	0,588	8,85	5,11	125	5,280
	76-91	0,178	6,9	0,015	0,088	0,510	8,01	4,52	120	5,808
2	0-13	0,992	7,2	0,080	0,323	1,104	10,8	25,3	569	10,56
	13-21	0,798	7,2	0,064	0,307	1,428	11,2	16,3	502	11,35
	21-43	0,714	6,4	0,065	0,182	1,278	9,56	14,4	480	12,14
	43-71	0,749	7,0	0,062	0,109	1,434	8,12	14,0	458	11,88
	71-150	0,663	6,7	0,057	0,087	1,920	8,48	13,4	446	11,72
35	0-23	0,607	6,6	0,053	0,307	1,194	7,54	20,6	211	10,98
	23-38	0,481	8,2	0,034	0,262	0,828	7,05	11,5	166	11,35
	38-50	0,569	6,9	0,048	0,182	1,146	8,47	10,6	151	10,56
	50-71	0,620	6,5	0,055	0,173	1,308	9,12	7,41	118	10,98

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	71-83	0,552	7,6	0,042	0,150	0,942	7,32	9,33	110	10,66
	83-115	0,465	8,4	0,032	0,141	0,756	6,05	7,74	106	11,03
	115-134	0,397	8,5	0,027	0,072	1,002	6,12	6,15	98	11,14
	134-158	0,327	11,2	0,017	0,065	0,756	6,54	4,52	96	11,08

The total nitrogen content fluctuates between 0.053-0.080% in the upper layer and 0.034-0.064% in the lower layers. The total phosphorus content is 0.307-0.323% in the upper layer of automorphic solonchaks and decreases toward the lower layers. Total potassium fluctuates between 1.104-1.194%.

The amount of mobile nitrogen in automorphic solonchaks of the studied territory is 7.54-12.4 mg/kg in the upper layer, phosphorus – 20.6-25.3 mg/kg, and in the lower and underlying horizons – 3.0-4.8 mg/kg.

The amount of exchangeable potassium in the upper horizon of automorphic solonchaks was observed within 370.0-478.0 mg/kg. According to the degree of provision with mobile nitrogen and phosphorus, they belong to the very low and low-provided groups, and according to the amount of mobile potassium, to the groups of medium and high-provided solonchaks.

The absorption capacity of soils and the composition of absorbed cations are considered important indicators that determine the properties and condition of the soil, the level of fertility and productivity, and an excess of the amount of absorbed magnesium and sodium in the soil absorption complex in the total amount of cations on saline soils leads to their alkalinization.

In the subsoil layer (up to the 20-30-70 cm layer) dark brown, very dense layers are formed, which have a strong negative impact on the normal growth and development of plants.

Among the absorbed bases (cations), sodium (Na+) occupies a special place, which is characteristic of solonchaks and solonetz soils.

If sodium is less than 5% of the absorbed cations in the absorption complex, it does not cause negative conditions for the physicochemical properties of the soil and, on the contrary, is beneficial in terms of soil fertility.

If the proportion of sodium in the absorption capacity is more than 5%, this leads to the formation of undesirable chemical and physical properties in the soil, productivity decreases, and its higher amount makes the soil completely unsuitable for irrigated agriculture.

The presence of sodium in the absorption complex determines the alkaline environment in the soil and causes the formation of soda (Na2CO3) in the soil solution, which is harmful to plants.

The absorption capacity and the content of absorbed cations of residual coastal automorphic solonchaks of the dried bottom of the Aral Sea are given in Table 3, it shows that the amount of absorbed bases (absorption capacity) in the upper layer of residual coastal automorphic solonchaks is 10.75-34.80 mg-eq, and in the lower layers 16.57-16.80 mg-eq in 100 g of soil.

The composition of absorbed cations in the soils of the dried bottom of the Aral Sea contains comparatively more magnesium and sodium cations, the amount of calcium from the total is 11.49-31.63%, magnesium 1.09-3.53%, and sodium - 20.18-54.65%, mainly consisting of soils with varying degrees of solonetzization (<10% mg/kg).

Table 3.
Absorption capacity and composition of absorbed cations of residual coastal automorphic salt marshes of the dried bottom of the Aral Sea

№ section	Depth of horizon, cm	In mg-eq per 100 g of soil.				Total (mg-eq)	In % of total.			
		Ca^{++}	Mg^{++}	K^{+}	Na^{+}		Ca^{++}	Mg^{++}	K^{+}	Na^{+}
1	0-20	3,4	4,8	0,38	2,17	10,75	31,63	44,65	3,53	20,18
	20-44	4,1	6,8	0,38	5,15	16,43	24,95	41,39	2,31	31,34
	44-64	3,9	7,7	0,25	5,15	17,00	22,94	45,29	1,47	30,29
	64-76	4,1	7,8	0,25	5,15	17,30	23,70	45,08	1,44	29,77
	76-91	4,2	7,2	0,25	5,15	16,80	25,00	42,86	1,49	30,65
2	0-13	4,0	11,4	0,38	19,02	34,80	11,49	31,72	1,09	54,65
	13-21	4,0	11,3	0,38	19,02	34,70	11,53	31,79	1,09	54,81

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	21-43	4,0	10,07	0,38	17,03	32,11	12,46	31,36	1,18	53,04
	43-71	3,9	10,7	0,25	19,2	33,87	11,51	31,59	0,74	56,15
	71-150	4,5	8,8	0,25	3,02	16,57	27,16	53,11	1,51	18,22

CONCLUSIONS

In conclusion, it should be noted that the soils of the dried bottom of the Aral Sea, where the studies were conducted, are groups with very low levels of humus and nutrients, these soils consist mainly of saline horizons, and the results of the study indicate that the soils in these areas are formed slowly. Among the elementary soil processes of the Aral Sea area, first of all, a special place is occupied by salinization-desalinization, salt migration, claying, oxidation-reduction processes, decomposition of organic residues, humus synthesis, DE humification.

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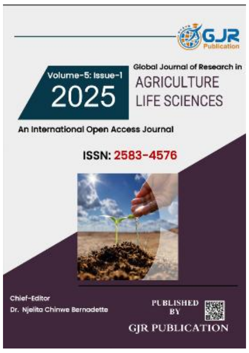

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